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# Comparison of Performance on the Shipley Institute of Living Scale, Air Traffic Control Specialist Selection Test, and FAA Academy Screen

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16. Abstract  This study was conducted to establish norms for ATCS personnel on a group test of intellectual functioning, the Shipley Institute of Living Scale (SILS), to screen subjects for future research on the effects of Air Traffic Control Specialist (ATCS) related stressors on complex task performance. The SILS provides both verbal (Vocabulary) and cognitive performance (Abstraction) measures of general intellectual functioning. The relationship between SILS and performance of ATCSs in the FAA Academy Nonradar Screen Program (NSP) was also assessed. ATCSs undergo a two-stage selection process: (a) the Office of Personnel Management (OPM) Air Traffic Control Specialist Battery and (b) the NSP, a nine-week performance-based screening course at the FAA Academy. The Shipley was administered to three entering groups of new hires (N=563) upon their arrival at the FAA Academy. SILS scores were converted to estimated WAIS-R Full Scale intelligence scores. The SILS measures were compared to scores (a) on the OPM selection battery and (b) in the NSP. SILS Total, Abstraction, and estimated WAIS-R scores were better predictors of NSP performance than were the SILS Vocabulary Subtest scores. Moderate correlations were found between the final academy score and the SILS and OPM measures. ATCS applicants scored higher on the Abstraction Subtest than the Vocabulary Subtest. ATCSs tend to be above average in intelligence, and tests of cognitive performance tend to be better predictors of overall NSP performance than verbal measures. The normative data can serve as an effective general intelligence screen for subjects involved in ATCS-related research.			
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# COMPARISON OF PERFORMANCE ON THE SHIPLEY INSTITUTE OF LIVING SCALE, AIR TRAFFIC CONTROL SPECIALIST SELECTION TEST AND FAA ACADEMY SCREEN

Current research to evaluate the effects of stressors for Air Traffic Control Specialists (ATCSs) on performance, physiological, biochemical, and subjective responses requires use of non-ATCS subjects in the laboratory. This prompted efforts to find screening measures for selecting non-ATCS research subjects with characteristics similar to the ATCS population. The present study was conducted to establish normative data for ATCSs on a measure of general intelligence using the Shipley Institute of Living Scale (SILS) to supplement screening criteria regarding health, educational level, and work history.

While a broad body of literature exists on selection of ATCSs, limited data have been reported concerning the average IQ of this population. Brokaw (1957) reported data from the California Testing Board Test of Mental Maturity; however, he only reported correlations of the sub-test scores with other aptitude tests. Karson and O'Dell reported data from the intelligence factor on the 16 Personality Factor Test (16PF) for 20,933 ATCSs in 1974. This ATCS group was found to have scores on this measure of intelligence nearly one standard deviation above the general population, or comparable to a Wechsler IQ score of about 115. The 16PF scores on the intelligence factor (B) from a more recent ATCS applicant group (Schroeder and Dollar, 1989) were identical to those of Karson and O'Dell (1974).

For purposes of this study, a relatively short, easily administered global measure of intelligence was required. The Shipley Institute of Living Scale (SILS) was selected because it 1) provides both verbal (vocabulary) and cognitive performance (abstraction) measures of general intelligence functioning; 2) can be administered in a short amount of time to a large group; 3) provides estimated Wechsler Adult Intelligence Scale-Revised (WAIS-R) Full Scale Intelligence scores; 4) has reasonable test-retest reliabilities and validity (Martin, Friedmeyer, Sterne, and Brittain, 1977; Goodman, Streiner, and Woodward, 1974; and Zachary, 1986); 5) has been widely used (Martin, Blair, and Vickers, 1979; Young and Rearden, 1979; and Guilberstadt, Lushene

and Buegel, 1976); and 6) has been used previously for subject selection in aviation-related research (Mertens and Collins, 1986). However, no data had been collected on the ATCS population.

Normative data on the SILS was collected on a sample of ATCS students entering the FAA Academy for future reference in selecting non-ATCS research subjects for air traffic control related research. In addition, this provided an opportunity to investigate the relationship between general intelligence, as measured by the SILS, and ATCS selection measures which include the Office of Personnel Management (OPM) Air Traffic Control test battery and the FAA Academy nonradar screen program (NSP).

## METHOD

### Subjects

Three groups of students (N=563) entering the FAA Academy in September 1990 and in August and October 1991 were used for this study. At that time, ATCS applicants underwent a two stage selection process, (a) administration of the Office of Personnel Management (OPM) Air Traffic Control Specialist Test Battery and (b) participation in the nonradar screen program (NSP), a nine week performance-based screening course at the FAA Academy in Oklahoma City. Students from this sample who withdrew prior to completing the NSP, those who had previously participated in the NSP, and those for whom OPM data were not available, were excluded from the sample. There were 414 of the total 563 students who were included in the final sample. Twenty-nine percent (121) of the final sample were women and 79% (328) were non-minorities. Fifty-nine percent (243) of the final sample reported having completed some college, while 31% (128) reported completing a college degree. The remaining 10% (43) completed high school. The average age of this final sample was 26.1 (age range from 19 to 34). All students in the final sample had successfully completed the first stage of the selection process; that is, they had received a score of 70 or better on the OPM battery.

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## **Procedure**

The SILS (1939) was administered to students upon their arrival at the FAA Academy as part of a three hour experimental testing session during orientation. Administration of the test was conducted according to the protocol in the SILS manual (Zachary, 1986). Students were allowed the designated 10 minutes for each of the two SILS sections, Vocabulary and Abstraction. Participation was voluntary and did not influence their Academy scores. The test was administered immediately following a 15 minute break. Following the orientation period, students proceeded into the nine week nonradar screen program. Biographical, OPM, and Academy NSP performance scores were obtained after students completed the NSP from a data base maintained by the Selection and Validation Research Section at the Civil Aeromedical Institute.

## **Measures**

The SILS yields two raw scores, Vocabulary and Abstraction, and a total score resulting from adding the weighted scores in which Abstraction receives a weight of 2. SILS total scores were converted to estimated WAIS-R scores in accordance with the age-referenced conversion tables in the SILS manual.

The Office of Personnel Management (OPM) Air Traffic Control rating consists of a composite score from the ATC test battery plus applicable veteran's points. The ATCS test battery is comprised of an abstract reasoning test (ABSR), as well as the Multiplex Controller Aptitude Test (MCAT). These are described in more detail elsewhere (Manning, Kegg, and Collins, 1988). The MCAT receives a weight of 4, while the Abstract Reasoning receives a weight of 1 in the composite calculations. The Occupational Knowledge Test (OKT) assesses the applicant's knowledge of Air Traffic rules and regulations. Points, up to 15, are added to the OPM rating for scores on the OKT over 50. Veteran's points are added to the composite.

The nine week Academy NSP was composed of two components: academics and laboratory (Della Rocco, Manning, and Wing, 1991). Thirteen performance measures were collected on each student during the NSP. The NSP final composite score (COMP) is comprised of twelve component scores as described below.

In the academic component, students were taught air traffic control (ATC) rules and procedures. Six performance measures were taken from multiple choice academic exams and a map test of the synthetic airspace. These received a weight in the composite of 20%. Scores from four multiple-choice tests and the map test were combined into a Block Test Average (BA). The final multiple-choice exam was the Comprehensive Course Test (CCT).

In the laboratory component, students were asked to demonstrate application of ATC rules and procedures in scripted 30 minute scenarios. Six standardized laboratory problems were formally graded. A student received a composite of two scores from a grading instructor on each problem. The first score, the technical assessment (TA), was a numeric assessment of the student's errors in application of ATC rules and procedures. The second score, the instructor assessment (IA), was a subjective instructor rating of the student's global performance on the problem. The student's lowest of the six graded laboratory problems was dropped from the final comprehensive NSP score. Thus, five of the scores were from graded laboratory problems and received a weight of 60% in the final score. These are reported for this study as the average of the five problems (AVL5). Finally, a timed multiple choice final exam, the Controller Skills Test (CST), comprised 20% of the final NSP score.

Students with NSP final composite scores of 70 or greater passed and proceeded into air traffic training. A final composite score of less than 70 resulted in failure and separation from the occupation.

## **Analyses**

Two analyses were conducted in this study. The first analysis was designed to determine whether or not successful students achieved significantly higher scores on the SILS than unsuccessful students. A multivariate analysis of variance (MANOVA) was utilized to compare mean SILS scores. The second analysis was conducted to determine the correlations between SILS scores and OPM and NSP scores. Because students entering the Academy had already been screened by the OPM Air Traffic Test Battery, it was important to correct for the restriction in the range of SILS scores caused by selection based on the OPM battery (Boone and Lewis, 1978;

Thorndike, 1949). To correct for restriction in range, population OPM scores and variance were calculated from data supplied to the Civil Aeromedical Institute by the Office of Personnel Management for persons reporting a date of availability between January 1988 and December 1989 (N=3,484).

## RESULTS

Of the 414 ATCS students in final sample, 233 (56.3%) passed the Academy NSP, 181 (43.7%) failed. The average estimated WAIS-R for the group of 414 Academy entrants was 109.8 (sd=5.9). The average

**TABLE 1. Mean Scores on the SILS by Academy Status**

SILS SCORES	ACADEMY STATUS			
	Passed (N=233)		Failed (N=181)	
	AVE.	SD	AVE.	SD
Vocabulary	31.9	3.8	31.0	3.5
Abstraction	36.2	3.1	34.9	3.9
Total	68.0	5.8	65.8	5.8
WAIS-R (estimated)	110.8	5.8	108.6	5.7

Shipley scores for the sample were as follows: Vocabulary 31.4 (sd=3.7); Abstraction 35.7 (sd=3.5); and Total 67.0 (sd=5.9).

The first analysis conducted for this study compared the performance of those who passed the Academy and those who failed. Table 1 presents descriptive statistics for scores on the SILS by final Academy Status.

Results of a Multivariate Analysis of Variance comparing SILS scores of passing students to those who failed were significant ( $F(4,409)=5.15, p<.001$ ). Analysis of Variance for each measure ( $df=1,412$ ) revealed that students who passed the Academy scored significantly higher on all SILS measures (Vocabulary  $F=6.64, p<.01$ ; Abstraction  $F=15.11, p<.001$ ; Total  $F=14.17, p<.001$ ; WAIS-R  $F=14.58, p<.001$ ).

The second analysis calculated Pearson correlations between SILS and both sets of ATCS selection measures—OPM and NSP. Table 2 presents correlations between OPM and SILS measures. Both unadjusted correlations and correlations adjusted for the restriction in range due to prior selection of subjects by the OPM exam are presented.

**TABLE 2. Correlations between SILS and OPM Scores**

Unadjusted for Restriction in Range by OPM				
OPM TEST MEASURES	SILS Scores			
	Vocabulary	Abstraction	Total	WAIS-R
Multiplex Controller Aptitude Test (MCAT)	.13**	.10*	.14**	.13**
Abstract Reasoning (ABSR)	.09	.18**	.17**	.17**
Occupational Knowledge Test (OKT)	.08	.01	.05	.03
OPM Rating	.11*	.08	.12*	.08
Adjusted for Restriction in Range by OPM				
OPM TEST MEASURES	SILS Scores			
	Vocabulary	Abstraction	Total	WAIS-R
Multiplex Controller Aptitude Test (MCAT)	.33	.26	.36	.33
Abstract Reasoning (ABSR)	.10	.19	.18	.18
Occupational Knowledge Test (OKT)	.07	.01	.04	.03
OPM Rating	.34	.26	.37	.26
*p<.05 **p<.01				

**TABLE 3. Correlations Between SILS and NSP Performance Measures**

Unadjusted for Restriction in Range by OPM				
NSP	SILS Scores			WAIS-R
	Vocabulary	Abstraction	Total	
Block Average (BA)	.14**	.19**	.20**	.18**
Comprehensive Course Test (CCT)	.16**	.18**	.21**	.18**
Average 5 of 6 Labs (AVL5)	.09	.23**	.20**	.20**
Controller Skills Test (CST)	.21**	.30**	.30**	.30**
Final Comprehensive Score (COMP)	.14**	.27**	.24**	.24**
** p<.01				
Adjusted for Restriction in Range by OPM				
NSP	SILS Scores			WAIS-R
	Vocabulary	Abstraction	Total	
Block Average (BA)	.30	.29	.36	.28
Comprehensive Course Test (CCT)	.28	.27	.33	.27
Average 5 of 6 Labs (AVL5)	.27	.33	.36	.30
Controller Skills Test (CST)	.35	.38	.43	.38
Final Comprehensive Score (COMP)	.34	.38	.43	.38

The correlation between scores from SILS Abstraction and the OPM Abstract Reasoning, although statistically significant, was notably low (.18), suggesting the possibility of differences in what each test measures. The highest adjusted correlations were found between all SILS scores and MCAT and OPM Rating.

Table 3 presents correlations between NSP performance measures and SILS scores. Correlations were adjusted for restriction in range of SILS scores due to prior OPM selection utilizing Thorndike's three variable case formula (Thorndike, 1949).

These correlations revealed that the Abstraction scores were somewhat better than the Vocabulary at predicting NSP performance. This was particularly true for the skill-based performance measures, specifically the graded laboratory problems and the Controller Skills Test. Among the SILS measures, the adjusted SILS Total score was the best predictor of NSP performance. Table 4 presents correlations between OPM and NSP scores.

Review of Table 4 reveals that correlations between the SILS Abstraction and NSP measures from Table 3 were notably higher than the correlations between OPM Abstract Reasoning (ABSR) and NSP measures. OPM Rating had the highest adjusted correlations with the skill-based NSP measures. The OKT correlations with NSP performance measures are unusually high in this sample when compared to previous reports (Della Rocco, et al., 1991).

## DISCUSSION

The purpose of this study was to administer a relatively short, global measure of intelligence to ATCSs in order to collect normative data and assess the relationship between SILS measures and well-investigated ATCS selection measures. Few studies had reported IQ data for this population and none had been reported for the SILS.

Data were collected from a sample of 414 ATCSs prior to entering the second stage of the ATCS selection process, the Nonradar Screen Program. Of the people who passed, the average estimated WAIS-R scores were found to be 110.8 (sd=6). Thus, as a group, ATCSs tend

**TABLE 4. Correlations between OPM Scores and NSP Performance Measures**

Unadjusted for Restriction in Range by OPM					
NSP	OPM Scores				Rating
	MCAT	ABSR	OKT		
Block Average (BA)	.11*	.12*	.31**		.22**
Comprehensive Course Test (CCT)	.10*	.04	.29**		.16**
Average 5 of 6 Labs (AVL5)	.16**	.14**	.25**		.24**
Controller Skills Test (CST)	.19**	.10*	.23**		.22**
Final Comprehensive Score	.18**	.14**	.28**		.25**
** p<.01					
Adjusted for Restriction in Range by OPM					
NSP	OPM Scores				Rating
	MCAT	ABSR	OKT		
MCAT ABSR OKT Rating					
Block Average (BA)	.29	.13	.28		.60
Comprehensive Course Test (CCT)	.26	.04	.26		.47
Average 5 of 6 Labs (AVL5)	.40	.15	.22		.63
Controller Skills Test (CST)	.46	.11	.21		.60
Final Comprehensive Score	.44	.15	.25		.65

to be above average in intelligence. This finding is similar to the findings of Karson and O'Dell (1974). The students who passed the NSP were found to have scored significantly higher than unsuccessful students on each of the SILS measures. Correlations between the SILS and ATCS selection measures, OPM and NSP scores respectively, were found to be low to moderate, but similar to correlations found in early work on ATCS selection (Brokaw, 1984). Because of the research leading to the use of an abstract reasoning test in the OPM battery (Collins, Boone, and VanDeventer, 1984), it was anticipated that the Abstraction would be a better predictor of NSP performance than the Vocabulary. This was found to be the case.

Specifically, the Abstraction scores were found to correlate better than Vocabulary scores with the performance-based NSP measures (i.e., the laboratory grades and the Controller Skills Test). Comparison of the adjusted correlations from OPM and NSP scores in Table 4 with those of the SILS and NSP scores from Table 3 suggests that the MCAT and SILS Total were comparable predictors of NSP performance. The OPM Rating was the best predictor of NSP performance. Although MCAT and OPM Rating would be desirable for use in selection of subjects in our ATCS stressor

studies, they are controlled tests and not available outside the ATCS selection process.

The correlation between SILS Abstraction and the abstract reasoning test on the OPM battery was found to be only .18. Even though this was significant, it would suggest that the tests measured different aptitudes or abilities. A closer examination of the OPM test reveals that it measures nonverbal reasoning, while the SILS is more of a verbal reasoning measure.

The average age of the sample was relatively young (26) because of the maximum age restriction of age 30 for initial entry into the ATCS occupation. Research indicates that age is positively related to vocabulary scores and negatively related to abstraction (Zachary, 1986). Zachary also reports that abstract thinking declines in older adults while vocabulary scores generally increase during the formative adult years and remain virtually unchanged into old age. For purposes of matching non-ATCS research subjects to ATCSs on intelligence, caution is advised when generalizing these findings to older subjects because of the restricted range of age of participants in this study.



The data derived from this study provided normative data for use of the SILS as a screening tool for non-ATCS subjects in air traffic related research. Because of the prior selection of this sample on the OPM and the restricted age range, generalization of these data to the ATCS population, to selecting older subjects, and to selecting subjects from different cultural groups requires additional research.

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